What is claimed is:

1. A method for forming quantum tunneling devices, said method comprising the steps of:

providing a quantum well, said quantum well comprising a composite material, said composite material comprising at least a first and a second material; and processing said quantum well so as to form at least one segregated quantum tunneling structure encased within a shell comprised of a material arising from processing said composite material, wherein each said segregated quantum structure is substantially comprised of said first material.

2. The method according to claim 1 wherein said composite material comprises a material selected from the group consisting of: composites comprising silicon, composites comprising germanium, composites comprising carbon, a silicon-germanium composite, a silicon-carbon composite, a germanium-carbon composite, a silicon-tin composite, a silicon-germanium-carbon composite, a silicon-germanium-carbon-tin composite, a gallium-arsenic composite, an indium-arsenic composite, an aluminum-arsenic composite, an aluminum-gallium-arsenic composite, an indium-gallium-arsenic composite, an indium-phosphorous composite, an indium-antimony composite, a gallium-antimony composite, an aluminum-antimony composite, an indium-gallium-antimony composite, a gallium-aluminum-antimony composite, an indium-gallium-antimony composite, a gallium-aluminum-antimony composite, an indium-aluminum-antimony composite, an indium-gallium-aluminum-antimony composite, an indium-nitrogen composite, a gallium-nitrogen composite, an aluminum-nitrogen composite, an indium-gallium-nitrogen composite, a gallium-aluminum-nitrogen composite, an indium-gallium-aluminum-nitrogen composite, an

indium-gallium-arsenic-nitrogen composite, a zinc-sulfur composite, a zinc-selenium composite, a zinc-tellurium composite, a cadmium-sulfur composite, a cadmium-tellurium composite, a mercury-sulfur composite, a mercury-selenium composite, a mercury-tellurium composite, a mercury-cadmium-tellurium composite, and mixtures thereof.

3. The method according to claim 1 wherein at least a portion of said shell is sufficiently thin enough to permit quantum tunneling of electrons from a first segregated quantum structure to a second structure selected from the group consisting of segregated quantum structures and electrodes.

4. The method according to claim 1 wherein said shell is reduced in thickness after said processing.

5. The method according to claim 1 wherein said processing of said quantum well is accomplished by a process selected from the group consisting of: oxidation, reduction, and nitridation.

6. The method according to claim 1 wherein said segregated quantum structure has no dimension greater than about 500 nanometers.

7. The method according to claim 1 further comprising the step of: applying a mask to said quantum well.

8. The method according to claim 1 further comprising the steps of:

removing at least a portion of said material arising from said processing of said composite material from said shell thereby thinning said shell and forming a thinned quantum well; and

re-processing said thinned quantum well.

9. The method according to claim 8 wherein said re-processing is accomplished by a process selected from the group consisting of: oxidation, reduction, and nitridation.

10. The method according to claim 1 wherein each said segregated quantum structure is separated from each other segregated quantum structure by said material arising from said processing of said composite material.

11. A quantum tunneling device formed in accordance with the method of claim 1.

12. A method for forming quantum tunneling devices, said method comprising:

providing a quantum well, said quantum well comprising at least three layers, each of said at least three layers comprising a first material, wherein at least one of said at least three layers additionally comprises at least a second material; and

processing said quantum well so as to form at least one segregated quantum structure comprising at least said second material encased in a material arising from processing said first material.

13. The method according to claim 12 wherein each said layer comprising said second material is disposed between at least two layers not comprising said second material.

14. The method according to claim 12 wherein said first material is selected from the group consisting of silicon, germanium, carbon, tin, gallium, arsenic, indium, aluminum, boron, phosphorus, antimony, nitrogen, zinc, sulfur, selenium, tellurium, cadmium, mercury, lead, and mixtures thereof.

15. The method according to claim 12 wherein said first material comprises a component selected from the group consisting of elements of group IIA of the periodic table, elements of group IIIA of the periodic table, elements of group IVA of the periodic table, elements of group VA of the periodic table, elements of group VIA of the periodic table, and mixtures thereof.

16. The method according to claim 12 wherein said second material is selected from the group consisting of silicon, germanium, carbon, tin, gallium, arsenic, aluminum, indium, boron, phosphorus, antimony, nitrogen, zinc, sulfur, selenium, tellurium, cadmium, mercury, lead, and mixtures thereof.

17. The method according to claim 12 wherein said second material is selected from the group consisting of elements of group IIA of the periodic table, elements of group IIIA of the periodic table, elements of group IVA of the periodic table, elements of group VA of the periodic table, elements of group VIA of the periodic table, and mixtures thereof.

18. The method according to claim 12 wherein said processing of said quantum well is accomplished by a process selected from the group consisting of oxidation, reduction, and nitridation.

19. The method according to claim 12 wherein at least a portion of said first material encasing said at least one segregated quantum structure is sufficiently thin enough to permit quantum tunneling of electrons from a first segregated quantum structure to a second structure selected from the group consisting of segregated quantum structures and electrodes.

20. A quantum tunneling device formed in accordance with the method of claim 12.

21. A method for forming quantum tunneling devices, said method comprising:

growing a quantum well on a substrate, said quantum well comprising at least a first material and a second material;

patterning a mask on said quantum well;

etching said quantum well so as to form a pillar; and

processing said pillar so as to convert said first material thereby forming an altered first material and causing said second material to form at least one segregated quantum structure embedded in said altered first material.

22. The method according to claim 21 comprising the additional steps of:

etching said altered first material so as to form a re-etched pillar; and

subjecting said re-etched pillar to a process so as to further alter said re-etched pillar.

23. The method according to claim 21 wherein said quantum well comprises at least three layers each comprising said first material, wherein at least one said layer further comprises said second material.

24. The method according to claim 23 wherein each said layer comprising a second material is disposed between at least two layers substantially not comprising said second material.

25. The method according to claim 21 wherein said substrate comprises a material selected from the group consisting of silicon, germanium, a silicon-carbon mixture, an indium-arsenic mixture, a gallium-arsenic mixture, an aluminum-arsenic mixture, an indium-phosphorus mixture, a gallium-phosphorus mixture, an aluminum-phosphorus mixture, an indium-antimony mixture, an aluminum-antimony mixture, an indium-nitrogen mixture, a gallium-nitrogen mixture, an aluminum-nitrogen mixture, an indium-arsenic mixture, a gallium-antimony mixture, sapphire, alumina, diamond, and mixtures thereof.

26. The method according to claim 21 wherein said first material is selected from the group consisting of silicon, germanium, carbon, tin, gallium, arsenic, indium, aluminum, phosphorus, boron, antimony, nitrogen, zinc, sulfur, selenium, tellurium, cadmium, mercury, lead, and mixtures thereof.

27. The method according to claim 21 wherein said first material is selected from the group consisting of elements of group IIA of the periodic table, elements of group IIIA of the periodic table, elements of group IVA of the periodic table, elements of group VA of the periodic table, elements of group VIA of the periodic table, and mixtures thereof.

28. The method according to claim 21 wherein said second material is selected from the group consisting of silicon, germanium, carbon, tin, gallium, arsenic, indium, aluminum, phosphorus, boron, antimony, nitrogen, zinc, sulfur, selenium, tellurium, cadmium, mercury, lead, and mixtures thereof.

29. The method according to claim 21 wherein said mask is patterned by a process selected from the group consisting of electron-beam lithography, contact lithography, projection lithography, self-assembly through modification by wetting and de-wetting, and nano-imprinting.

30. The method according to claim 21 wherein said mask comprises a material selected from the group consisting of silicon, silicon dioxide, silicon nitride, titanium, gold, platinum, nickel, chromium, aluminum, silver, tantalum, molybdenum and mixtures thereof.

31. The method according to claim 21 wherein said mask is a photoresist.

32. The method according to claim 21 wherein said mask has a diameter in the range of about 0.5 nanometers to about 500 nanometers.

33. The method according to claim 21 wherein said quantum well is etched by a process selected from the group consisting of plasma etching, wet etching with acidic solutions, wet etching with basic solution, anisotropic etching, isotropic etching, barrel etching, reactive ion etching, electron cyclotron resonance reactive ion etching, and inductively coupled plasma reactive ion etching.

34. The method according to claim 21 wherein said pillar has a diameter in the range of about 0.5 nanometers to about 500 nanometers.

35. The method according to claim 21 wherein each said at least one segregated quantum structure has a diameter of less than about 50 nanometers.

36. The method according to claim 21 wherein each said at least one segregated quantum tunneling structure is substantially crystalline.

37. The method according to claim 22 wherein said altered first material is etched by a process selected from the group consisting of plasma etching, wet etching with acidic solutions, wet etching with basic solution, anisotropic etching, isotropic etching, barrel etching, reactive ion etching, electron cyclotron resonance reactive ion etching, and inductively coupled plasma reactive ion etching.

38. The method according to claim 22 wherein said re-etched pillar has a diameter less than said diameter of said pillar.

39. A quantum tunneling device formed in accordance with the method of claim 21.

40. A quantum tunneling device comprising:

at least one segregated quantum structure; and

a casing of a first material encapsulating said at least one segregated quantum structure, wherein said casing is sufficiently thin so as to permit quantum tunneling of electrons from a first segregated quantum structure to a structure selected form the group consisting of segregated quantum structures and electrodes.

41. The quantum tunneling device according to claim 40 wherein said at least one segregated quantum structure has a diameter of less than about 200 nanometers.

42. The quantum tunneling device according to claim 40 wherein said at least one segregated quantum tunneling structure has a diameter of less than about 50 nanometers.

43. The quantum tunneling device according to claim 40 wherein said segregated quantum structure comprises a material selected from the group consisting of silicon, germanium, carbon, tin, gallium, arsenic, indium, aluminum, phosphorus, boron, antimony, nitrogen, zinc, sulfur, selenium, tellurium, cadmium, mercury, lead, and mixtures thereof.

44. The quantum tunneling device according to claim 40 wherein said first material comprises a material selected from the group consisting of silicon, germanium,

carbon, tin, gallium, arsenic, indium, aluminum, phosphorus, antimony, nitrogen, zinc, sulfur, selenium, tellurium, cadmium, mercury, and mixtures thereof.

45. The quantum tunneling device according to claim 40 wherein said first material has been altered by a process selected from the group consisting of oxidation, reduction, and nitridation.

46. The quantum tunneling device according to claim 40 wherein said first material comprises a semi-conductive material selected from the group consisting of elements of group IIA of the periodic table, elements of group IIIA of the periodic table, elements of group IVA of the periodic table, elements of group VA of the periodic table, elements of group VIA of the periodic table, and mixtures thereof.

47. The quantum tunneling device according to claim 40 wherein said quantum tunneling device has no dimension greater than 500 nanometers.

48. The quantum tunneling device according to claim 40 wherein said casing is substantially non-crystalline.

49. The quantum tunneling device according to claim 40 wherein said at least one segregated quantum structure is substantially crystalline.

50. The quantum tunneling device according to claim 40 having at least two segregated quantum structures, wherein said at least two segregated quantum

structures are substantially aligned along an axis so as to form a segregated quantum tunneling wire.

51. An electronic device comprising:

a quantum tunneling device, said quantum tunneling device comprising at least one segregated quantum structure and a casing of a first material encapsulating said at least one segregated quantum structure; and

at least one electrode, wherein said casing is sufficiently thin so as to permit quantum tunneling of electrons from a segregated quantum structure to said at least one said electrode.

52. The electronic device according to claim 51 wherein each said segregated quantum structure has a diameter less than about 200 nanometers.

53. The electronic device according to claim 51 wherein each said segregated quantum structure has a diameter less than about 100 nanometers.

54. The electronic device according to claim 51 wherein each said segregated quantum structure has a diameter not exceeding about 25 nanometers.

55. The electronic device according to claim 51 wherein said segregated quantum structure comprises a material selected from the group consisting of silicon, germanium, carbon, tin, gallium, arsenic, indium, aluminum, phosphorus, boron, antimony, nitrogen, zinc, sulfur, selenium, tellurium, cadmium, mercury, lead, and mixtures thereof.

56. The electronic device according to claim 51 wherein said first material comprises a material selected from the group consisting of silicon, germanium, carbon, tin, gallium, arsenic, indium, aluminum, phosphorus, boron, antimony, nitrogen, zinc, sulfur, selenium, tellurium, cadmium, mercury, lead, and mixtures thereof.

57. The electronic device according to claim 51 wherein said first material comprises a semi-conductive material selected from the group consisting of elements of group IIA of the periodic table, elements of group IIIA of the periodic table, elements of group IVA of the periodic table, elements of group VA of the periodic table, elements of group VIA of the periodic table, and mixtures thereof.

58. The electronic device according to claim 51 wherein said first material has been altered by a process selected from the group consisting of oxidation, reduction, and nitradation.

59. The electronic device according to claim 51 wherein said at least one electrode comprises a material selected from the group consisting of lithium, beryllium, boron, carbon, nitrogen, oxygen, aluminum, silicon, calcium, titanium, vanadium, manganese, iron, cobalt, nickel, copper, zinc, gallium, germanium, arsenic, yttrium, zirconium, niobium, molybdenum, palladium, silver, cadmium, indium, tin, antimony, barium, tantalum, tungsten, iridium, platinum, gold, mercury, thallium, lead, bismuth, and mixtures thereof.

60. The electronic device according to claim 51 wherein said segregated quantum structure is substantially crystalline.

61. The electronic device according to claim 51 wherein said casing is substantially non-crystalline.

62. The electronic device according to claim 51 wherein said electronic device is operational at temperatures in excess of about 1K.

63. The electronic device according to claim 51, wherein said electronic device is operational at temperatures in excess of about 200K.

64. The electronic device according to claim 51, comprising at least two segregated quantum structures, wherein each said segregated quantum structure is encapsulated in said casing of said first material and wherein each said segregated quantum structure is separated from each other segregated quantum structure by a sufficiently thin layer of said first material so as to permit quantum tunneling of electrons from a given segregated quantum structure to at least one other segregated quantum structure.

65. The electronic device according to claim 64, wherein said at least two segregated quantum structures are substantially aligned along an axis so as to form a segregated quantum tunneling wire.

66. A quantum-dot cellular automata node switch comprising:

at least two quantum tunneling devices, each said quantum tunneling device comprising at least one segregated quantum structure and a casing of a first material encapsulating said segregated quantum structure, wherein each said quantum tunneling device is adjacent to at least one other said quantum tunneling device such that at least one said segregated quantum structure in a first quantum tunneling device is separated by a distance from at least one said segregated quantum structure in a second quantum tunneling device, and wherein said distance is sufficiently small so as to permit coulombic interaction between electrons from at least one said segregated quantum structure in said first quantum tunneling device and at least one said segregated quantum structure in said second quantum tunneling device; and at least two electrodes, each said electrode separated from a said segregated quantum structure by a distance, wherein said distance is sufficiently small so as to permit coulombic interaction between electrons of said segregated quantum tunneling structure and said electrode.

67. The quantum-dot cellular automata node switch according to claim 66 wherein each said segregated quantum structure has a diameter less than about 200 nanometers.

68. The quantum-dot cellular automata node switch according to claim 66 wherein each said segregated quantum structure has a diameter less than about 50 nanometers.

69. The quantum-dot cellular automata node switch according to claim 66 wherein each said segregated quantum structure has a diameter not exceeding about 10 nanometers.

70. The quantum-dot cellular automata node switch according to claim 66 wherein said segregated quantum structure comprises a material selected from the group consisting of silicon, germanium, carbon, tin, gallium, arsenic, indium, aluminum, phosphorus, boron, antimony, nitrogen, zinc, sulfur, selenium, tellurium, cadmium, mercury, lead, and mixtures thereof.

71. The quantum-dot cellular automata node switch according to claim 66 wherein said first material comprises a material selected from the group consisting of silicon, germanium, carbon, tin, gallium, arsenic, indium, phosphorus, boron, antimony, aluminum, nitrogen, zinc, sulfur, selenium, tellurium, cadmium, mercury, lead, and mixtures thereof.

72. The quantum-dot cellular automata node switch according to claim 66 wherein said first material comprises a semi-conductive material selected from the group consisting of elements of group IIA of the periodic table, elements of group IIIA of the periodic table, elements of group IVA of the periodic table, elements of group VA of the periodic table, elements of group VIA of the periodic table, and mixtures thereof.

73. The quantum-dot cellular automata node switch according to claim 66 wherein said first material has been altered by a process selected from the group consisting of oxidation, reduction, and nitradation.

74. The quantum-dot cellular automata node switch according to claim 66 wherein each said at least one electrode comprises a material selected from the group consisting of lithium, beryllium, boron, carbon, nitrogen, oxygen, aluminum, silicon, calcium, titanium, vanadium, manganese, iron, cobalt, nickel, copper, zinc, gallium, germanium, arsenic, yttrium, zirconium, niobium, molybdenum, palladium, silver, cadmium, indium, tin, antimony, barium, tantalum, tungsten, iridium, platinum, gold, mercury, thallium, lead, bismuth, and mixtures thereof.

75. The quantum-dot cellular automata node switch according to claim 66 wherein at least one of said at least two segregated quantum structures is substantially crystalline.

76. The quantum-dot cellular automata node switch according to claim 66 wherein said casing is substantially non-crystalline.

77. The quantum-dot cellular automata node switch according to claim 66 wherein said quantum-dot cellular automata node switch is operational at temperatures in excess of about 2K.

78. The quantum-dot cellular automata node switch according to claim 66 wherein said quantum-dot cellular automata node switch is operational at temperatures in excess of about 200K.

79. A quantum-dot cellular automata node switch comprising:

a quantum tunneling device, said quantum tunneling device comprising a casing of a first material and at least two segregated quantum structures, wherein each said segregated quantum structure is encapsulated in said casing of said first material, and wherein each said segregated quantum structure is separated from each other segregated quantum structure by a sufficiently thin layer of said first material so as to permit coulombic interaction between electrons from a first segregated quantum structure to a second segregated quantum structure; and

at least two electrodes, each said electrode separated from a respective segregated quantum structure by said casing, said casing being sufficiently thin so as to permit coulombic interaction between electrons from said electrode to said respective segregated quantum structure.

80. The quantum-dot cellular automata node switch according to claim 79 wherein each said segregated quantum structure has a diameter less than about 200 nanometers.

81. The quantum-dot cellular automata node switch according to claim 79 wherein each said segregated quantum structure has a diameter less than about 100 nanometers.

82. The quantum-dot cellular automata node switch according to claim 79 wherein each said segregated quantum structure has a diameter less than about 20 nanometers.

83. The quantum-dot cellular automata node switch according to claim 79 wherein said segregated quantum structure comprises a material selected from the group consisting of silicon, germanium, carbon, tin, gallium, arsenic, indium, aluminum, boron, phosphorus, antimony, nitrogen, zinc, sulfur, selenium, tellurium, cadmium, mercury, lead, and mixtures thereof.

84. The quantum-dot cellular automata node switch according to claim 79 wherein said first material comprises a material selected from the group consisting of silicon, germanium, carbon, tin, gallium, arsenic, indium, aluminum, phosphorus, antimony, nitrogen, zinc, sulfur, selenium, tellurium, cadmium, mercury, boron, lead, and mixtures thereof.

85. The quantum-dot cellular automata node switch according to claim 79 wherein said first material comprises a semi-conductive material selected from the group consisting of elements of group IIA of the periodic table, elements of group IIIA of the periodic table, elements of group IVA of the periodic table, elements of group VA of the periodic table, elements of group VIA of the periodic table, and mixtures thereof.

86. The quantum-dot cellular automata node switch according to claim 79 wherein said first material has been altered by a process selected from the group consisting of oxidation, reduction, and nitradation.

87. The quantum-dot cellular automata node switch according to claim 79 wherein each said at least two electrodes are constructed from a material selected from the group consisting of lithium, beryllium, boron, carbon, nitrogen, oxygen, aluminum,

silicon, calcium, titanium, vanadium, manganese, iron, cobalt, nickel, copper, zinc, gallium, germanium, arsenic, yttrium, zirconium, niobium, molybdenum, palladium, silver, cadmium, indium, tin, antimony, barium, tantalum, tungsten, iridium, platinum, gold, mercury, thallium, lead, bismuth, and mixtures thereof.

88. The quantum-dot cellular automata node switch according to claim 79 wherein at least one of said at least two segregated quantum structures is substantially crystalline.

89. The quantum-dot cellular automata node switch according to claim 79 wherein said casing is substantially non-crystalline.

90. The quantum-dot cellular automata node switch according to claim 79 wherein said quantum-dot cellular automata node switch is operational at temperatures in excess of about 2K.

91. The quantum-dot cellular automata node switch according to claim 79 wherein said quantum-dot cellular automata node switch is operational at temperatures in excess of about 50K.